2019 HSC Engineering Studies Marking Guidelines

Section I

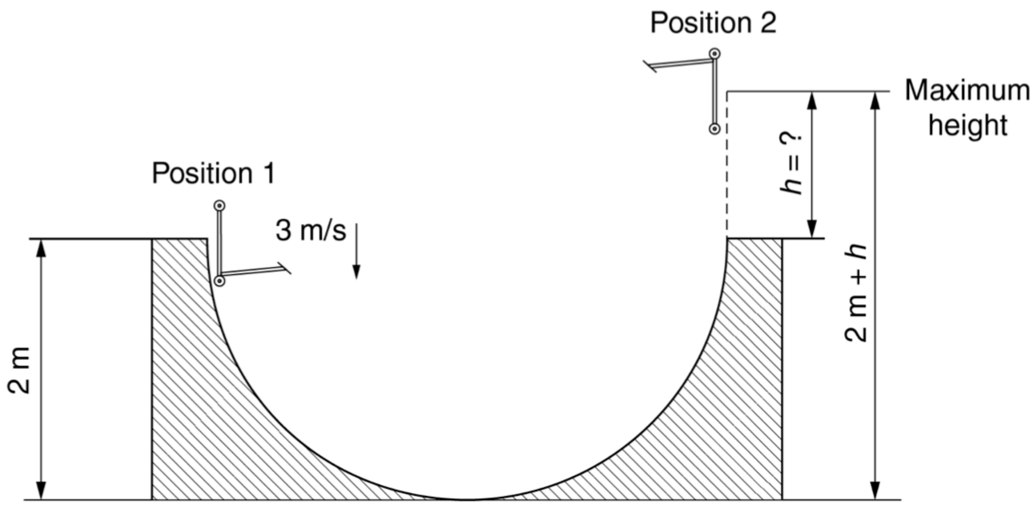
Multiple-choice Answer Key

Question	Answer
1	C
2	B
3	D
4	B
5	B
6	D
7	C
8	A
9	D
10	D
11	A
12	B
13	B
14	A
15	B
16	C
17	C
18	A
19	C
20	D

Question 23 (a)

Criteria	Marks
• Shows relevant working in the correct calculation of the maximum height reached by the scooter above the other side	3
• Makes significant progress towards the calculation of the maximum height of the scooter above the other side	2
• Applies an appropriate method	1

Sample answer:



- Mechanical energy is conserved
- $KE_2 = 0$ J
- $g = 10$ m/s^2
- $h_2 = 2$ metres + h

∴ KE2 + PE2 = KE1 + PE1

$0 + mgh_2 = ½\ mv_1^2 + mgh_1$

$10 \times (2 + h) = (½ \times 3^2) + (10 \times 2)$

$20 + 10h = 4.5 + 20$

$h = 4.5 \div 10$

h = 0.45 metres

Question 23 (b)

Criteria	Marks
• Shows relevant working in the correct calculation of the stored energy	2
• Applies an appropriate method	1

Sample answer:

Multiply the voltage of the battery by the current it delivers an hour.

12 V × 18 A × 1 h = 216 W in 1 h (Power = Volts × Current)

Therefore, power stored = 216 Wh

1 Watt = 1 Joule consumed per second
1 W = 1 J/s
1 Wh = 3600 J

Therefore, energy stored is:

216 Wh × 3600 J = 777 600 J

Energy stored = 777.6 kJ

Question 23 (c)

Criteria	Marks
• Calculates the mass of the scooter correctly	3
• Makes some significant progress towards calculating the mass of the scooter	2
• Applies an appropriate method	1

Sample answer:

$F = mg$

$P = \frac{F}{A}$

$A = 1200 \times 10^{-6}\,\text{m}^2$

$P = 300 \times 10^3\,\text{Pa}$

$\therefore F = PA$

$= 300 \times 10^3 \times 1200 \times 10^{-6}$

$= 300 \times 1200 \times 10^{-3}$

$= 30 \times 12\,\text{N}$

$= 360\,\text{N}$ per tyre

2 tyres, $\therefore$ load $= 720\,\text{N}$
Weight of rider $= 650\,\text{N}$
$\therefore$ weight of scooter $= 70\,\text{N}$

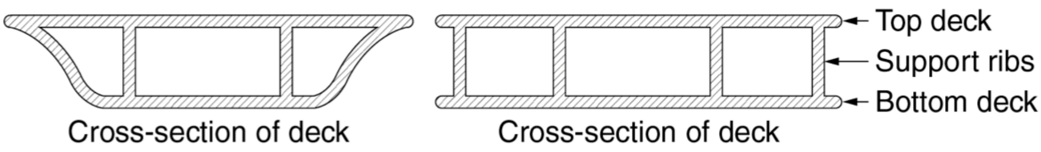
$$\text{Mass} = \frac{F}{g} = \frac{70}{10} = 7\ \text{kg}$$

Question 23 (d)

Criteria	Marks
• Describes ONE suitable design modification to the scooter deck supported by a labelled sketch	3
• Outlines ONE design modification to the scooter deck supported by some relevant sketching	2
• Provides some relevant information	1

Sample answer:

Modify the cross-section of the deck by adding longitudinal ribbing without adding extra mass. This will result in a thinner wall structure and increase the distance of the neutral axis from the bottom of the deck and hence a decrease in deflection.



Question 24 (a)

Criteria	Marks
• Provides comparisons between the use of composite materials and the use of metals	3
• Provides some comparison between the use of composite materials and the use of metals	2
• Provides some relevant information	1

Sample answer:

Composite materials are lighter, but require specialised equipment (such as an autoclave) to manufacture carbon fibre epoxy composite beams. Metals are heavier, but most can be fabricated in open air using boilermaking/fabrication tools such as gas torches, welders and plasma cutters. Due to their lighter weight, the carbon fibre epoxy composites are easier to manoeuvre and workers can position them more easily when they are working on them.

Answers could include:

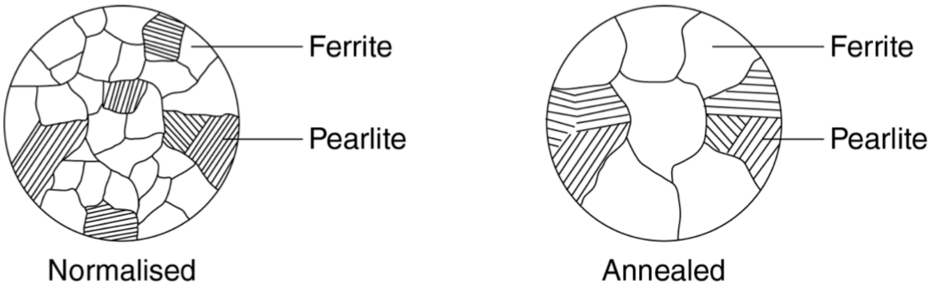
The tooling used to make a carbon fibre epoxy mould is likely to be more accurate than a fabrication shop. However, a metal beam can be built to similar tolerances.

The wing spar is subjected to significant fatigue loads. When fabricated, the metal beam is likely to contain stress raisers (corners of drilled holes, scratches) and microvoids in welds that initiate fatigue. The carbon fibre composites are not susceptible to fatigue cracking.

Question 24 (b) (i)

Criteria	Marks
• Draws TWO correctly labelled microstructures	2
• Sketches some relevant information	1

Sample answer:



Question 24 (b) (ii)

Criteria	Marks
• Provides an explanation of how normalising steel improves its suitability	2
• Provides some relevant information	1

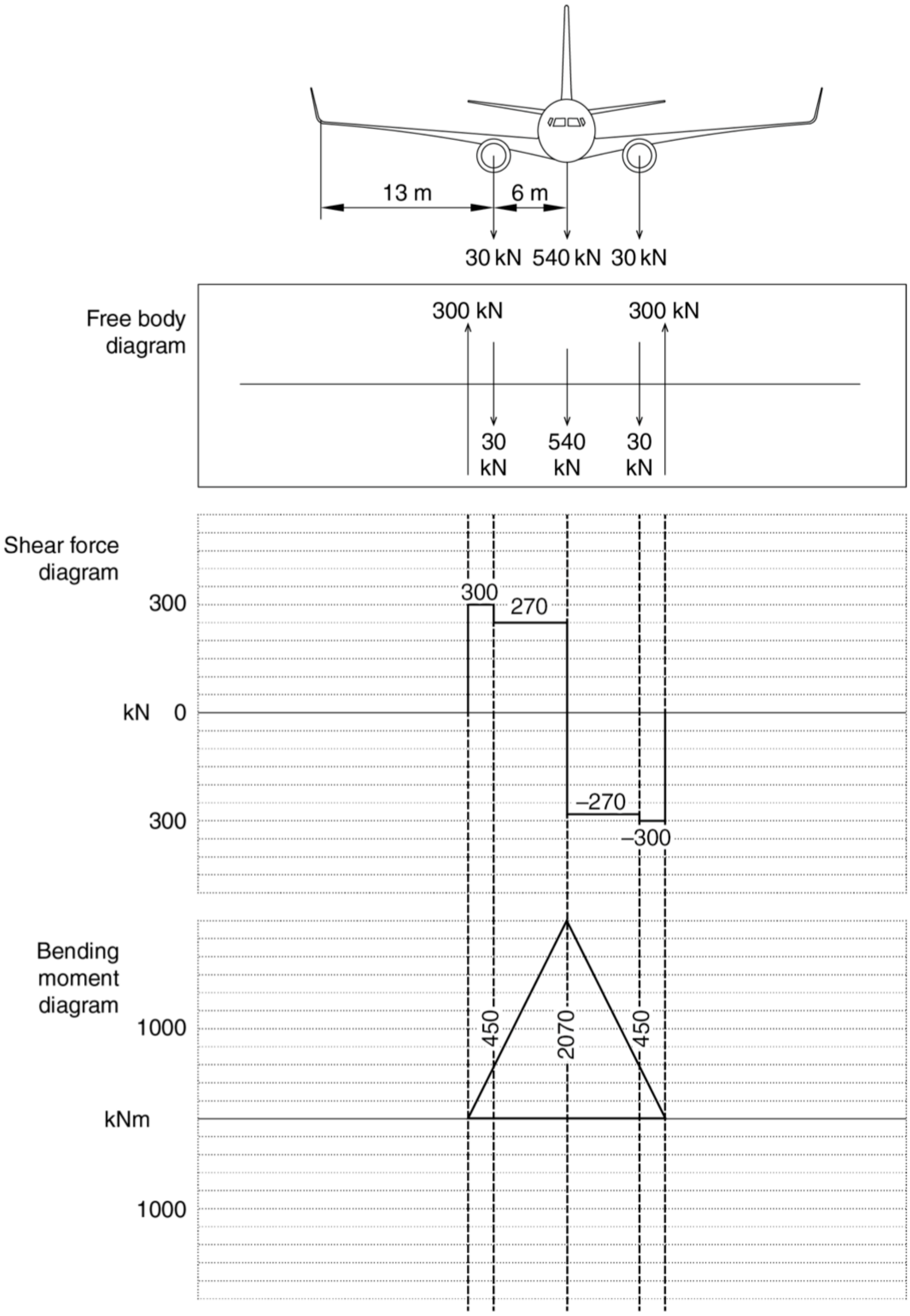
Sample answer:

The finer and more uniform grains produced by normalising greatly improve the strength of the steel.

Question 24 (c)

Criteria	Marks
• Produces labelled free body, shear force and bending moment diagrams correctly	6
• Produces more than one substantially correct and labelled free body, shear force and bending moment diagrams	4–5
• Produces a correct and labelled shear force diagram OR bending moment diagram or free body diagram	3
• Demonstrates some understanding of a shear force diagram OR a bending moment diagram or free body diagram	2
• Applies an appropriate method	1

Sample answer:



Question 25 (a)

Criteria	Marks
• Explains how an understanding of the effects of drag can be used to improve the design of racing yacht hulls	3
• Provides some information about how the effects of drag can be used to improve the design of racing yacht hulls	2
• Provides some relevant information	1

Sample answer:

An understanding of drag can be used to improve the design of racing yachts as follows:

- minimised drag means maximum forward thrust hence increased speed
- polished surfaces minimise drag
- streamlined shape of the hull minimises vortices.

Answers could include:

- finite element analysis to minimise induced turbulence
- minimise weight through choosing appropriate materials.

Question 25 (b)

Criteria	Marks
• Completes the table with appropriate properties	3
• Partially completes the table with appropriate properties	2
• Provides some relevant information	1

Sample answer:

Material	Property
Kevlar® aramid fibre	A high tensile strength fibre providing tear resistance and light weight.
Carbon fibre epoxy composite	A low weight, stiff composite with high tensile strength.
Aluminium alloy	High strength to weight ratio as well as toughness.

Answers could include:

Carbon fibre epoxy may also be used because it has a smooth surface, can be moulded into complex aerodynamic shapes and provides weight reduction.

Question 25 (c)

Criteria	Marks
• Explains why engineers use CAD to design and model intricate components	3
• Provides some information about why engineers use CAD to design and model intricate components	2
• Provides some relevant information	1

Sample answer:

Engineers use CAD to assist them in designing intricate components as it allows for a number of immediate outputs. This may include a visual image, 3D representation and printing of hardcopies as well as finite element analysis. CAD also allows the engineer to modify drawings easily, share the drawing as a collaborative file and see these changes across all related documents.

Question 25 (d)

Criteria	Marks
• Explains how the hydrofoil can lift the board out of the water at high speeds	3
• Provides some features about how the hydrofoil can lift the board out of the water at high speeds	2
• Provides some relevant information	1

Sample answer:

As the board moves forwards the water flows over and around the hydrofoil. The shape of the hydrofoil, which is similar to an aircraft wing, creates a difference in pressure above and below the foil: low pressure above and higher pressure below. This difference means that the higher pressure lifts the hydrofoil and therefore the board upwards. Lift is also created by the deflection of water downwards at the trailing edge of the hydrofoil. This results in an upward reaction force. Above a critical speed, the board is lifted out of the water.

Question 26 (a)

Criteria	Marks
• Provides an explanation of how the generator converted mechanical energy from pedalling into electrical energy	3
• Provides some information about how the generator converted mechanical energy from pedalling into electrical energy	2
• Provides some relevant information	1

Sample answer:

The generator is made of a magnet within a coil of wire. The pedalling spins the magnet and as it spins, electricity is generated within the coil through the process of magnetic induction. The electrical energy generated is used to power the radio transceiver. As the generator spinning speed increases, the voltage also increases.

Question 26 (b) (i)

Criteria	Marks
• Completes the table with appropriate entries	5
• Substantially completes the table with appropriate entries	3–4
• Partially completes the table with appropriate entries	2
• Provides some relevant information	1

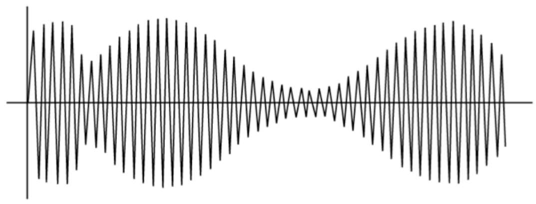
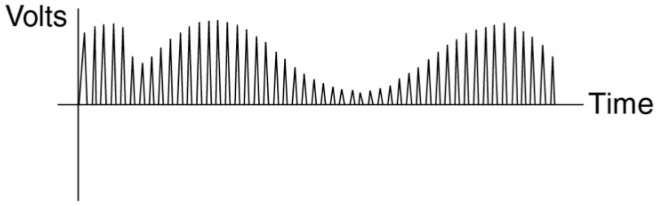
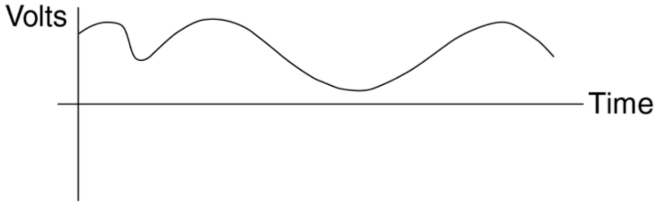
Sample answer:

Component	*Function*
Antenna	Picks up the electromagnetic signal and feeds it to the circuit
Capacitor – Fixed	This smooths out the rectified signal to produce a demodulated waveform
Capacitor – Variable	Works in tandem with the coil to have the circuit resonate at a single frequency. This allows the circuit to detect a single frequency band instead of all possible frequencies
Earth	Acts as a negative pole for the system
Signal diode	Only allows positive current to flow through the circuit, turning the received signal into a half-waveform which is capable of being rectified

Question 26 (b) (ii)

Criteria	Marks
• Correctly draws the waveform at positions B and C as identified on the circuit	2
• Provides some relevant information	1

Sample answer:

Position	*Waveform*
A	
B	
C	

Question 26 (b) (iii)

Criteria	Marks
• Explains why the speaker needs high impedance	2
• Provides some relevant information	1

Sample answer:

The radio shown works without an external power source. The power for the speaker comes from the signal that the aerial picks up. At a very high resistance (impedance) the speaker is able to generate an audible signal at a very low current.

Answers could include:

- Power = VI = (IR) × I = I^2R
- A high impedance on the earphones means that the coil/tuning capacitor sensitivity improves, meaning that the incoming signal can be tuned in more accurately
- If the impedance is low, then the power consumed by the earpiece is low and the sound is inaudible.

Question 27 (a)

Criteria	Marks
• Explains why detailed drawings are used	2
• Provides some relevant information	1

Sample answer:

For the Structural Engineer to communicate information about individual parts, a scaled ‘Detail Drawing’ would be created. This would be drawn at a scale suitable to show all details so that it could be manufactured accurately and the parts to be fitted together. Possible scales would be 2:1, 5:1 and 10:1. If detailed drawings are not used the parts can be manufactured inaccurately.

Answers could include:

Communication between engineers and construction workers.

Question 27 (b) (i)

Criteria	Marks
• Shows relevant working in the correct calculation of the lock pin diameter and gives the minimum diameter	3
• Makes significant progress towards calculating lock pin diameter	2
• Applies an appropriate method	1

Sample answer:

$E = 210GPa$

$FoS = 5$

Total load $= 3.5$ kN

Shear Strength of Pin$\left(\sigma_s\right) = 240$ MPa

Allowable $\sigma_s = \dfrac{240}{5}$

Allowable $\sigma_s = 48$ MPa

$$\sigma_s = \frac{P}{2A} \ (\because \text{double shear})$$

$$2A = \frac{P}{\sigma_s}$$

$$A = \frac{P}{\sigma_s}$$

$$A = \frac{3500}{2 \times 48}$$

$$A = 36.4533 \text{ mm}^2$$

$$A = \frac{\pi d^2}{4}$$

$$d = \sqrt{\frac{4A}{\pi}}$$

$$d = \sqrt{\frac{4 \times 36.4583}{\pi}}$$

$$d = 6.813 \text{ mm}$$

OR

$$\sigma_s = \frac{P}{2A} (\because \text{double shear})$$

$$\sigma_s = \frac{P}{2\left(\frac{\pi d^2}{4}\right)}$$

$$\sigma_s = \frac{2P}{\pi d^2}$$

$$d^2 = \frac{2P}{\sigma_s \pi}$$

$$d = \sqrt{\frac{2P}{\sigma_s \pi}}$$

$$d = \sqrt{\frac{2 \times 3500}{48 \times \pi}}$$

$$d = 6.813 \text{ mm}$$

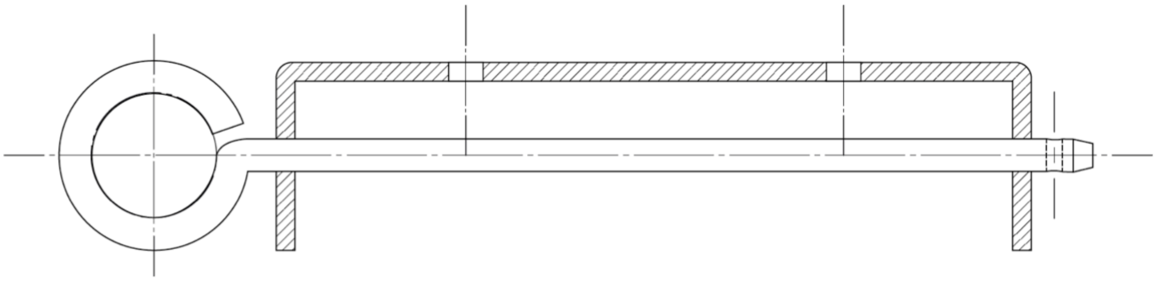
From table of available diameters, next available diameter up = 7 mm

Therefore, use a pin with a diameter of 7 mm.

Question 27 (b) (ii)

Criteria	Marks
• Provides a completed sectioned top view using AS 1100 conventions	3
• Provides a substantially correct sectioned top view using AS 1100 conventions	2
• Provides some aspects of a correct projection	1

Sample answer:



2019 HSC Engineering Studies Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Aeronautical engineering – historical and societal influences – p32	H1.1
2	1	Telecommunications engineering – engineering materials – p36	H1.2
3	1	Telecommunications engineering – engineering electronics/electricity – p37	H3.1
4	1	Civil structures – communication – p26, p29, p33 Personal and public transport – communication – p26, p29, p33 Aeronautical engineering – communication – p26, p29, p33	H3.3
5	1	Civil structures – communication – p26	H3.3
6	1	Personal and public transport – engineering electronics/electricity – p29	H3.1, H3.3
7	1	Personal and public transport – engineering mechanics – p28	H3.1
8	1	Aeronautical engineering – scope of the profession – p31	H1.1
9	1	Civil structures – engineering materials – p26	H3.1, H3.3
10	1	Aeronautical engineering – engineering mechanics/hydraulics – p32	H3.1
11	1	Civil structures – historical and societal influences – p24	H4.1, H4.2, H4.3
12	1	Aeronautical engineering – engineering mechanics/hydraulics, scope – p31, 32	H4.1
13	1	Personal and public transport – engineering mechanics – p28	H3.1
14	1	Telecommunications engineering – engineering electricity/electronics – p37	H3.1, H3.3
15	1	Aeronautical engineering – engineering materials – p33	H1.2
16	1	Civil structures – engineering materials/historical influences – p26 Personal and public transport – engineering materials/historical influences p27	H1.2, H2.2
17	1	Personal and public transport – engineering materials – p28, p29	H1.2, H2.1
18	1	Personal and public transport – engineering mechanics – p28	H3.1, H3.3
19	1	Personal and public transport – communication – p29	H3.1, H3.3
20	1	Civil structures – engineering mechanics – p25	H3.1, H3.3

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	3	Civil structures – engineering materials – p25	H1.2, H2.1
21 (b)	2	Civil structures – engineering materials – p26	H1.2, H2.1
21 (c)	4	Civil structures – engineering materials, communications – p25, p26	H1.2, H2.1

Question	Marks	Content	Syllabus outcomes
21 (d)	3	Civil structures – engineering mechanics – p25	H3.1, H3.3
22 (a)	3	Telecommunications engineering – scope of the profession – p36	H1.1, H4.3
22 (b)	3	Telecommunications engineering – engineering electricity/electronics – p37	H1.2, H2.2
22 (c)	6	Civil structures – engineering mechanics – p25	H3.1, H3.3
23 (a)	3	Personal and public transport – engineering mechanics – p28	H3.1, H3.3
23 (b)	2	Personal and public transport – engineering electricity/electronics – p29	H2.1, H3.1, H3.3
23 (c)	3	Civil structures – engineering mechanics – p25	H3.1, H3.3
23 (d)	3	Civil structures – engineering mechanics – p25	H1.2, H2.1
24 (a)	3	Aeronautical engineering – engineering materials – p33	H1.2, H2.1
24 (b) (i)	2	Personal and public transport – engineering materials – p28	H1.2, H2.1
24 (b) (ii)	2	Personal and public transport – engineering materials – p28	H1.2, H2.1
24 (c)	6	Aeronautical engineering – engineering mechanics – p32 Civil structures – engineering mechanics – p25	H3.1, H3.3
25 (a)	3	Aeronautical engineering – scope of the profession, engineering mechanics – p31, p32	H1.1, H2.2
25 (b)	3	Aeronautical engineering – scope of the profession, engineering materials – p31, p33	H1.1, H2.2, H4.1, H4.3
25 (c)	3	Aeronautical engineering – communication, scope of the profession – p31, p34	H1.2, H2.1
25 (d)	3	Aeronautical engineering – engineering mechanics – p32	H3.1, H3.3
26 (a)	3	Personal and public transport – engineering electricity/electronics – p29	H2.1, H3.1, H3.3
26 (b) (i)	5	Telecommunications engineering – engineering electricity/electronics – p37 Personal and public transport – simple circuits – p29	H2.1, H3.1, H3.3
26 (b) (ii)	2	Telecommunications engineering – engineering electricity/electronics – p37	H3.1, H3.3
26 (b) (iii)	2	Personal and public transport – engineering electricity/electronics –p29 Telecommunications engineering – engineering electricity/electronics – p37	H2.1, H3.1, H3.3
27 (a)	2	Aeronautical engineering – communication – p33	H3.1, H3.3
27 (b) (i)	3	Civil structures – engineering mechanics – p25	H3.1, H3.3
27 (b) (ii)	3	Personal and public transport – communication – p29	H3.1, H3.3